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ABSTRACT:

Strain Relief and Damage in Highly Stretchable Layered Composites

J. Wilmers[1,2], P. Kowol[1], S. Bargmann[1,2]

[1]Chair of Solid Mechanics, University of Wuppertal, 42119 Wuppertal, Germany.
[2]Wuppertal Center for Smart Materials & Systems, University of Wuppertal, 42119 Wuppertal, Germany.

Stretchable electronics exploit the characteristics of soft biocompatible polymers and utilize microstructural designs to push the boundaries of brittle conductor materials. A novel approach aims to increase macroscopic stretchability by introduction of controlled cracks in the polymer substrate's surface [1]. The cracks are deliberately induced by a micropattern of soft island crack starters in the hardened surface.
Here, we study crack evolution in dependence of the micropattern design using numerical modeling [2]. A cohesive zone is used to capture the fracture behavior in the soft and hardened PDMS parts of a fully parameterized representative volume element [3]. We investigate the mechanical behavior of the layered polymer substrate and consider the influence of different material and geometry properties to analyze the damage behavior and strain relief capabilities of these structures. The results show that cracks and soft islands accommodate the majority of the applied macroscopic strain while the hardened surface remains mostly strain-free, indicating that electronic devices or metal thin films could be applied with minimal risk of damage. Moreover, the simulations reveal interactions between parameters, which allows to identify design principles for large usable surfaces on polymer substrates utilizing controlled cracking.

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